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Combined Vascular Reconstruction and Microvascular Muscle Flap Transfer for Salvage of Ischaemic Legs with Major Tissue Loss and Wound Complications

M. Lepäntalo*[1] and E. Tukiainen[2]

[1]*Division of Vascular Surgery, Department of Surgery and* [2]*Department of Plastic Surgery, Helsinki University, Central Hospital, Helsinki, Finland*

Objective: *To assess the safety and short-term efficacy of combined vascular revascularisation and free microvascular muscle flap transfer in patients with advanced lower limb ischaemia caused by occlusive arterial disease.*
Design: *A prospective follow-up study of 2–72 months.*
Setting: *Academic referral centre.*
Materials: *Consecutive first 15 patients with extensive tissue loss due to advanced leg ischaemia or wound complications after bypass surgery.*
Chief outcome measures: *Graft patency, free tissue transfer viability, amputation rate.*
Main results: *There was no perioperative mortality. The cumulative rates for secondary vascular patency, microvascular graft viability and limb salvage were 80%, 87% and 76% at one year provided that vessels and grafts that were functioning at the time of amputation were considered lost to follow-up rather than failed at that point. If, however, amputation was also regarded as vessel and graft failure the corresponding rates were 68%, 62% and 76%, respectively.*
Conclusions: *Combining microvascular muscle flap transfer with vascular reconstruction for salvage of legs with extended ischaemic tissue loss or wound complications after bypass surgery gave acceptable preliminary results and deserves an attempt in selected patients.*

Key Words: Critical leg ischaemia; Diabetes mellitus; Ischaemic tissue loss; Wound complications; Bypass surgery; Free tissue transfer.

Introduction

Chronic leg ischaemia is the most important indication for treatment in vascular surgery. It comprised 53% of all patients treated by vascular or endovascular surgery in the whole Finland in 1991–1992.[1] Arterial reconstruction is the standard method to improve tissue perfusion in chronic critical leg ischaemia.[2–6] Critical leg ischaemia is most often caused by diffuse, multisegment arterial disease necessitating long infra-inguinal reconstructions.[3,6] However, even a patent graft does not necessarily guarantee the salvage of the foot as advanced ischaemia, progressing gangrene and infection may cause irreversible tissue destruction necessitating major amputation. Repeated extensive debridement procedures are often unable to obtain secondary healing which even when successful often deforms the foot markedly. Microsurgical free tissue transfer for limb salvage in trauma and tumour surgery is routine,[7] but free tissue transfer in the face of prior vascular bypass has also been performed with success.[8] The use of this technique has been limited by the concerns over technical problems of microvascular anastomoses and high morbidity in arteriosclerotic patients with critical ischaemia.[9]

The aim of the present study was to assess the safety and short-term efficacy of combined vascular revascularisation and microvascular muscle transfer in patients with advanced lower limb ischaemia caused by occlusive arterial disease with or without diabetes.

Patients and Methods

A prospective follow-up study was initiated at the time of the first combined vascular reconstruction and

*Please address all correspondence to: Mauri Lepäntalo, Division of Vascular Surgery, Department of Surgery, Helsinki University, Central Hospital, Kasarmikatu 11-13, SF-00130 Helsinki, Finland.

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microvascular muscle transfer in 1989 performed jointly by a vascular and a plastic surgeon in Helsinki University Central Hospital. During the following 72 months, 15 joint ventures for leg salvage were performed (Table 1). Eleven were performed for critical leg ischaemia with major tissue loss, three for severe postoperative wound infection, and one for interval gangrene after femorotibial bypass. These tissue defects would traditionally have been impossible to heal despite revascularisation due to their large size, exposure of bone or tendon, underlying osteitis or exposed graft, or location on weight bearing areas. All patients were candidates for major amputation. Only patients with large lesions and major artery occlusions or risk for actual rupture of the graft were included. At the same time the number of patients treated for critical leg ischaemia in our institution was 772, 66% being treated with revascularisation, 19% with primary amputation and 15% conservatively.

Of the 15 patients, there were 10 men and five women, aged 55–84 years (mean 69 years). Eight were diabetic (Table 1). Patients with extensive tissue loss had chronic large tissue defects, all of more than 3 months' duration. All patients were assessed preoperatively in vascular laboratory by pressure measurements and Doppler evaluation. Ankle brachial index (ABI) were routinely measured, but only seven patients had compressible tibial arteries with a mean ABI of 0.23. Nine patients had poor Doppler signals with monophasic or aphasic waveforms at ankle level. In two patients no reliable Doppler signal could be achieved. Patients underwent angiography, which was performed selectively on the symptomatic side when a distal bypass was planned. Adequate arterial inflow was confirmed by Duplex assessment.

Arterial reconstructions were mainly bypass grafts to the ankle level (Table 1). The inflow procedure for the microvascular muscle transfer was performed simultaneously in six instances and in two instances part of an infected vein graft was also substituted by an arm vein and simultaneously covered by a microvascular muscle flap. In others the scheduled micro-

Table 1. Data summary for 15 patients who underwent vascular reconstruction and microvascular muscle transfer

Sex/ Age	DM	Lesion	ABI	Cause	Arterial reconstruction	Free flap	Delay	Immediate outcome ABI	Arterial	Flap	Leg	Follow-up (months)	Final outcome Arterial	Flap	Leg
Extensive ischaemic tissue loss															
M66	II	Heel	?	T	Femoropopliteal *ex situ* graft	FA	simult.	1.02	PP`	PH	S	72	PP	H	S
F62	II	Heel	MS	NI	SFA recanalisation by PTA and later femoropopliteal bypass	LD	4 wks	MS	PP	PH	S	45	SP	H	S
M67	II	TM stump	MS	I	Popliteopedal *in situ* graft	LD	8 wks	MS	PP	PH	S	17	PP	H	S
M72	I	Heel	MS	NI	Femoropedal *in situ* graft	RA	4 wks	MS	PP	SH	A	25	PP	H	BK/2
M85	II	Sole+ digital stumps	MS	NI	Popliteodistal *ex situ* graft to RA flap	RA	simult.	MS	PP	SH	S	10	F/6	H	S
F73	I	Forefoot	MS	NI	Tibiopedal *ex situ* graft	RA	5 wks	MS	PP	PH	S	2	PP	H	S
M67	I	Forefoot	MS	NI	Popliteotibial bypass	LD	simult.	MS	PP	PH	S	4	PP	H	S
M74	II	Achilles area	MS	T	Popliteadistal *ex situ* graft to LD flap	LD	simult.	MS	PP	PH	S	2	PP	H	S
M74	–	Forefoot	0.50	T	Femoropopliteal *in situ* graft	RA	simult.	0.57	PP	F	S	17	PP	F/0	S
F71	–	Leg	0.36	I	Iliacofemoral EA and Femorotibial *in situ* bypass	LD	simult.	0.92	PP	F	S	13	PP	F/0	S
M60	–	Forefoot	0	I	Aortobifemoral graft	LD	9 wks	0.43	PP	PH	S	17	PP	H	S
Wound complications with tissue loss after femorodistal reconstructive surgery															
M55	I	Foot	MS	S[1]	Popliteopedal *in situ* graft	LD†	2 wks	MS	SP	PH	S	18	F/5	H	BK/5
F83	–	Foot*	0.26	S[1]	Femoropedal *ex situ* graft	LD	1 wk	1.07	SP	PH	S	15	SP	H	S
F70	–	Foot*	0.25	S[1]	Femoropedal *in situ* graft	RA†	4 wks	1.07	SP	PH	S	16	SP	H	S
M55	–	Thigh	0	S[2]	Extended profundoplasty and femoropedal *in situ* graft	LD	5 mos.	0.61	PP	PH	S	23	PP	H	AK/4

Diabetes: I insulin dependent, II noninsulin dependent, –no diabetes.
ABI: Ankle brachial pressure index, MS not reliably measurable due to mediasclerosis.
Cause: I ischaemia, NI neuroischaemia, T primarily traumatic, S unhealed surgical incision, *Anastomotioc rupture. [1]Infected distal anastomosis and wound dehiscence after bypass to dorsalis pedis artery, [2]interval gangraena of the thigh after occlusion of the profundoplasty.
Free flap: LD microvascular latissimus dorsi muscle free flap with split thickness skin graft, RA corresponding rectus abdominis muscle free flap, FA fasciocutaneous radial forearm flap †corrected with interposition vein graft and free muscle flap.
Outcome: PP primary patency, SP secondary patency, PH primary healing, SH secondary healing necessitating additional procedures on the flap, F failure ie. occluded vein graft or lost free flap, S leg salvage, A amputation, BK below knee, AK above knee, /time interval in months between microvascular muscle transfer and adverse event.

vascular reconstruction was performed 4 to 9 weeks after vascular surgery. The inflow artery of the free muscle flap was anastomosed to the vein graft in nine patients, whereas in six patients the microvascular inflow was placed distal to the vascular reconstruction. Nine latissimus dorsi (Fig. 1) and five rectus abdominis muscle flaps were used. Latissimus dorsi flaps were usually preferred over rectus abdominis flaps because its long large pedicle is seldom affected by arteriosclerotic changes, which are often seen in inferior epigastric artery feeding the rectus abdominis muscle. On the other hand the poor general condition of some patients called for regional anaesthaesia and a supine position which necessitated the use of the rectus abdominis flap. Once a fasciocutaneous radial forearm flap was used to cover large defect on the heel and Achilles area. A two-team approach was used whenever appropriate to revascularise the leg or expose the recipient artery and vein, dissect the flap and debride the wound. Microvascular anastomoses were performed with the use of interrupted 8-0 polypropylene sutures. Surgeons used magnifying loupes with 4.5-fold magnification. Arterial anastomoses were made end to side whereas venous anastomoses were usually performed end to end to a deep system vein. ASA 250 mg/day was used as the only perioperative adjuvant drug. Patients were treated with antibiotics for 3–4 weeks according to ulcer bacteriology, wound healing and kidney function. Patients were kept in bed rest with the extremity slightly elevated and supported at least for seven days prior to gradual ambulation. Weight bearing was gradually started at 4–6 weeks.

The follow-up visits took place at 1, 3, 6 and 12 months and annually thereafter. The patency of vascular graft was assessed by pulse palpation, Doppler and pressure measurements and by Duplex when in doubt. The viability of the microvascular flap

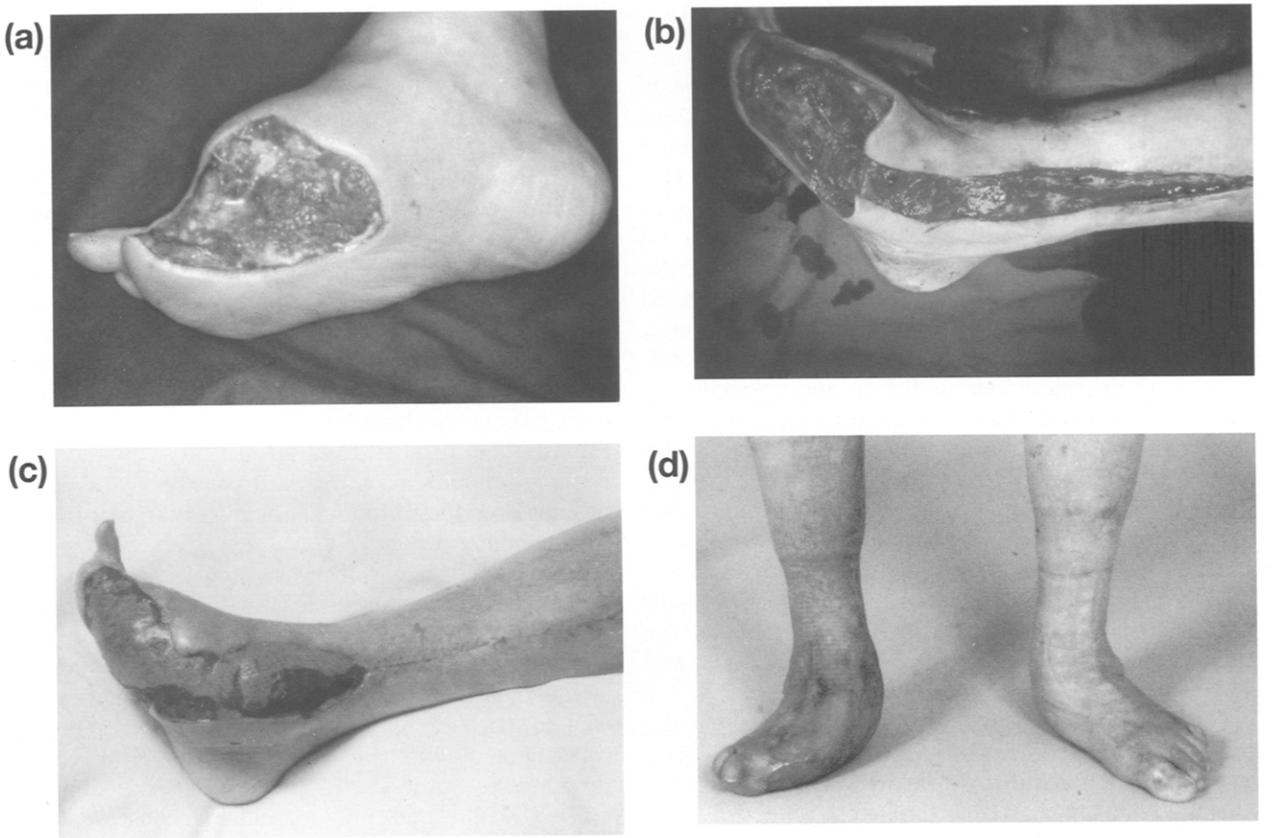

Fig. 1. Treatment of large ischaemic lesion with subsequent vascular reconstruction and microvascular muscle transfer in a 67-year-old diabetic man. (a) A I-III ray TMT-amputation with exposed bones and tendons after wound excision 8 weeks after popliteopedal bypass. (b) Peroperative view after additional wound excision and exposure of the popliteopedal vein graft. (c) Free latissimus dorsi muscle flap transfer covered with split skin with small areas of skin loss typical of diabetics 1 month postoperatively. (d) Final result 7 months postoperatively.

Table 2. Combined vascular reconstruction and microvascular muscle flap transfer and additional operations during the first 3 months

Characteristics	Simultaneous reconstructions	Sequential reconstructions	All
Principal reconstruction	6	9	15
Theatre time	9 h 27 min (7'09"–11'40")	10 h 42 min (8'55"–11'45")	10 h 15 min (7'09"–11'45")
Operation time	7 h 32 min (5'15"–9'22")	7 h 23 min (5'50"–8'10")	7 h 27 min (5'15"–9'22")
Vascular reoperations	1	3	4
Minor surgery	7	20	27
Total hospital stay	36 days (16–92)	68 days (28–135)	57 days (16–135)

was assessed clinically. The cumulative patency and leg salvage rates were calculated according to survival analysis by life-table method.

Results

The mean operation time was 7.5 h irrespective of whether the macro- and microvascular reconstructions were made simultaneously or in two subsequent operations (Table 2). When soft-tissue reconstruction was performed alone later, the mean theatre time was prolonged by one additional visit. There was no perioperative mortality in this series. Of the vascular procedures two immediate failures were encountered but the grafts stayed secondarily open, one after thrombectomy and the other after thrombectomy, ligation of an arteriovenous fistula and correction of the distal anastomosis. Two microvascular reoperations had to be done, one for the vein and the other for both anastomoses. These two muscle flaps, both in patients with simultaneous procedures, were lost due to flap necrosis and removed and the defects were covered with split thickness skin grafts. Furthermore, 27 minor procedures for transferred muscle flaps or local lesions in 13 patients were needed (Table 2). The total hospital stays ranged from 16 to 135 days and were somewhat longer after sequential repair.

One femoropedal bypass occluded distal to the microvascular anastomosis 5 months after the free muscle transfer requiring a below knee amputation 5 months later with a viable flap. At 1 year, two more legs were amputated, both of them diabetics with uncontrollable deep infection and osteomyelitis despite a patent vein graft and viable muscle transfer. These two amputations were done 2 months postoperatively at below-knee level and 6 months postoperatively at above-knee level, respectively. The cumulative primary vascular patency was 69% at 1 year. Secondary vascular patency, microvascular graft viability and limb salvage rates were 80%, 87% and 76% provided that vessels and grafts that were functioning at the time of amputation were considered lost to follow up rather than failed at that point. If, however, amputation were also regarded as vessel and graft failure the corresponding rates were 70%, 62% and 77%, respectively.

Apart from the three amputated patients, who all are institutionalized, one of them bed-ridden, two in wheelchairs, all other patients are mobile and able to live at home.

Discussion

Arterial reconstructions to pedal arteries are reported to have patencies of 68–95% at 1 year.[10–12] A step further in the attempt to salvage ischaemic legs with extended tissue loss has been the combination of bypass surgery with free muscle transfer using microsurgical techniques.[8,13–16] Before the advent of microvascular muscle transfer many severely ischaemic wounds of the distal leg, ankle and proximal foot required major amputation. The graft patency and flap viability in the present series was in accordance with the other small series available.[8,13–16] Leg salvage was somewhat worse than in other series,[14,16] mainly due to the loss of two legs with patent grafts but uncontrollable infection. Thus the status of the ischaemic lesion seems important as the presence of osteomyelitis appeared to have an adverse outcome. However, patients with diabetes were as good candidates for combined reconstruction as those without as observed by others.[8] Indeed, the presence of diabetes has not been found to make the microvascular muscle transfer more difficult.[17,18]

The combined approach of vascular reconstruction and microvascular muscle transfer does not lack problems. Musculocutaneous flaps around the foot and ankle tend to be bulky and their skin does not always tolerate weight bearing.[19,20] Therefore, skin was not used from the donor site. Transferred muscle was covered with split thickness skin graft as also reported by others.[14,19] The timing of combined macrovascular and microvascular reconstruction is controversial. Delayed microvascular reconstruction was preferred in the present series, because our impression was that during simultaneous reconstruction the outflow vein tended to be very small after long-standing critical ischaemia. This view was sup-

ported by the observation that both flap failures occurred in patients with simultaneous reconstructions. Furthermore, staging allows the surgeon to ensure patency of the bypass graft before the patient is subjected to a long and difficult free flap procedure. A similar strategy was reported by Cronenwett *et al.*[14] whereas Serletti *et al.*[16] gave preference whenever possible to simultaneous reconstructions. Another problem was that the success of both arterial reconstruction and free flap transfer did not guarantee salvage in a number of legs, mostly due to uncontrollable infection. This finding is in accordance with others.[16]

The appropriate management of advanced critical ischaemia is still a matter of debate. Vascular reconstructions have been shown to yield better mobility than amputation and to be less expensive in terms of total costs[3] but may be inadequate to obtain healing of extensive tissue defects. The published results of the initial experience from combining arterial reconstruction and free muscle transfer are promising and supported by the present data.[8,13–16] This development of both vascular and microvascular techniques thus gives an opportunity, at least in some patients, to salvage legs with chronic critical leg ischaemia and advanced tissue loss. Candidates for combining microvascular muscle transfer to femorodistal bypass surgery are those with exposed bone, major joint, recipient artery or graft as well as those in whom piecemeal amputations or major deformity of the foot can thus be prevented. The expenses of such treatment are high and it benefits probably only a very selected group of patients. Success requires team work between vascular and plastic surgeons. A Duplex surveillance program, though not systematically performed in the present study, is certainly required to detect severe asymptomatic stenoses, which endanger the graft, the muscle flap and the leg.

Wound complications may expose the graft—especially with distal tibial or pedal anastomoses. In these cases the tissue defect is caused by vascular surgery and can result in an exposed graft which may become infected and bleed. Microvascular muscle transfer offers a durable and safe way to handle infected, exposed and ruptured grafts after adequate debridement and necessary removal and repair of the grafts.

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